Journal of Experimental Psychology: General
2014, Vol. 143, No. 3, 1185–1198

0096-3445/14/$12.00 DOI: 10.1037/a0034207

Do Framing Effects Reveal Irrational Choice?

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Framing effects have long been viewed as compelling evidence of irrationality in human decision making, yet that view rests on the questionable assumption that numeric quantifiers used to convey the expected values of choice options are uniformly interpreted as exact values. Two experiments show that when the exactness of such quantifiers is made explicit by the experimenter, framing effects vanish. However, when the same quantifiers are given a lower bound (*at least*) meaning, the typical framing effect is found. A 3rd experiment confirmed that most people spontaneously interpret the quantifiers in standard framing tests as lower bounded and that their interpretations strongly moderate the framing effect. Notably, in each experiment, a significant majority of participants made rational choices, either choosing the option that maximized expected value (i.e., lives saved) or choosing consistently across frames when the options were of equal expected value.

Keywords: framing effects, decision making, rationality, numeric quantifiers

Making coherent choices is a basic requirement of rational decision making captured well by the principle of description invariance, a fundamental coherence axiom of rational-choice theories (Arrow, 1982; Tversky & Kahneman, 1986). Description invariance requires that a decision maker's choice among a set of options should not vary merely because they have been described or "framed" differently, provided that the alternative frames actually describe the identical option set (i.e., they are extensionally equivalent). Demonstrations of framing effects have been regarded as compelling evidence that people's choices are incoherent and, hence, irrational (Dawes, 1988; Shafir & LeBoeuf, 2002; Stanovich & West, 2000). In recent years, framing effects have even been used as negative indicators to measure decision competence (Bruine de Bruin, Parker, & Fischhoff, 2007) and critical thinking (West, Toplak, & Stanovich, 2008; but compare Stanovich & West, 2008).

Framing literature that purportedly supports the substantive irrationality claim focuses mainly on studies of "risky-choice" framing (Levin, Schneider, & Gaeth, 1998). In such studies, the decision maker is presented with two options to choose from: One option offers a certain outcome with both favorable and unfavorable components, whereas the other offers an uncertain outcome in which one possibility is better than the alternative certain outcome (indeed, entirely favorable) and the other possibility is worse (indeed, entirely unfavorable).[1] The two options are assumed to be equal in terms of their expected utility. However, as the reader shall see, the present research challenges that assumption.

Although the focus in this article is on risky-choice framing, given the impact it has had on the characterization of human rationality, it is worth noting at the outset that the present analysis has broader implications for framing manipulations that involve describing outcomes or events as potentials gains of a given magnitude versus potential losses of a complementary magnitude. Such framing manipulations include the other main types noted in Levin et al.'s (1998) taxonomy, including attribute framing (e.g., Levin & Gaeth, 1988) and health message framing (for a review, see Rothman & Salovey, 1997). Indeed, the research and conceptual analysis presented in this article are of relevance to the interpretation of virtually all types of framing effects that involve a reformulation of quantitative information conveyed to a receiver, such as re-describing a 90% chance of post-operative survival as a 10% chance of post-operative mortality. While there are examples of framing effects that do not involve the re-description of quantities in complementary ways, such as re-describing an earmarked tax as an offset (Hardisty, Johnson, & Weber, 2010), the vast majority of framing studies has focused on such manipulations and thus may be informed by the present research. Moreover, the issues raised here are of relevance to a wide array of everyday life

This article was published Online First August 26, 2013.

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Portions of this research were presented at the 12th International Conference on Thinking in London, England, on July 6, 2012. This research was supported by Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant 249537-07 and Department of National Defense Applied Research Program Project 15dm. I thank the following people: Nada Bishir, Irina Kapler, Philip Omorogbe, Karen Richards, Lee Unger, and Joseph Williams for their research assistance; Bart Geurts, Denis Hilton, Daniel Kahneman, Karl Teigen, and Neil Thomason for useful discussions of the ideas and findings presented in this article; and Sharon Thompson-Schill for her constructive feedback on drafts of this article.

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[1] Following Knight (1921/1964), the latter is often referred to as the *risky* option. However, Tombu and Mandel (2013) have found that a nontrivial proportion of participants perceive the certain option as riskier, especially when the options are framed negatively. Thus, the terms *certain* and *uncertain* are used in this article to refer to the respective options.

contexts in which decisions are made about how best to communicate information with numeric quantifiers to decision makers.

Re-Examining a Core Assumption in Framing Research

The most influential example of a risky-choice framing manipulation is Tversky and Kahneman's (1981) "Asian disease" problem (ADP). In the ADP, participants first read the following:

> Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:

Participants in a positive-framing condition were then asked to choose between Options A and B:

> If Program A is adopted, 200 people will be saved.
>
> If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved.

By comparison, participants in a negative-framing condition chose between Options C and D:

> If Program C is adopted, 400 people will die.
>
> If Program D is adopted, there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die.

With positive framing, 72% chose the certain option (A); but with negative framing, 78% chose the uncertain option (D).

The findings are theoretically significant because they (ostensibly) show that decision makers' choices among the same options could be systematically affected by trivial variations in description—namely, that decision makers are incoherent because they violate the description invariance principle. As noted earlier, that conclusion—and indeed the validity of the framing manipulation—rests on a foundational assumption of *extensional equivalence*. Quite simply, it states that the certain option in the positive frame is identical to the certain option in the negative frame—and likewise for the uncertain options across frames.

With few notable exceptions (e.g., Jou, Shanteau, & Harris, 1996; Kühberger & Tanner, 2010; Macdonald, 1986; Mandel, 2001), the extensional-equivalence assumption has remained virtually unchallenged in the framing literature. Kahneman and Tversky (1984) themselves claimed, "it is easy to verify that options C and D in Problem 2 are undistinguishable in real terms from options A and B in Problem 1, respectively" (p. 343), leading them to conclude that "the failure of invariance is both pervasive and robust" (p. 343). Likewise, in an influential review, Levin et al. (1998), declaring their belief in the extensional-equivalence assumption, stated, "Problems such as the Asian disease problem provide 'pure' framing effects because the *same* outcomes are alternatively phrased *as though* they were gains or as though they were losses" (p. 180, italics in original). Acceptance of the extensional-equivalence assumption in the ADP has been just as strong outside of psychology. For instance, in a recent article in *Economics and Philosophy*, after describing the ADP, Gold and List (2004) advised readers as follows: "Note that A and C are extensionally equivalent. They denote the same vaccination program, where precisely 200 people will be saved and 400 will die" (p. 255).

A critical, but neglected, question is how one might verify that the reframed options are identical. Tversky and Kahneman (1981; Kahneman & Tversky, 1984) offered no more than an appeal to intuition. Regarding the certain options (A and C), whose equivalence seems the more controversial because they are not fully described in terms of expected outcome (i.e., nothing is said about the remaining 400 lives in the positive-framing condition or about the remaining 200 lives in the negative-framing condition), the implicit argument in support of extensional equivalence is easy enough to construct: If there are 600 threatened lives and 200 are saved (A), then that leaves 400 who will die (C). In other words, the arithmetic fact that $600 - 200 = 400$ is taken as proof that the alternative frames describe equivalent expected outcomes. In effect, framing is construed here as merely "refocusing" attention from the proportion 200/600 to the complementary proportion 400/600 (Mandel, 2008).

The *proof-by-arithmetic argument* is widely accepted in the literature (e.g., Fagley, 1993; Kühberger, Schulte-Mecklenbeck, & Perner, 1999; Levin et al., 1998), even by skeptics of coherence theorists' conclusions, such as Hammond (2000), who nevertheless advised readers to "take another look at the options and do the arithmetic" (p. 61) lest they remain skeptical about the reframed options' equivalence. Indeed, even McKenzie and colleagues (McKenzie, 2004; McKenzie & Nelson, 2003), who proposed that positive and negative frames convey different information to receivers because of their varying conversational implicatures, still concede that in problems like the ADP the frames are extensionally (or as they put it, logically) equivalent.

Widespread belief in the proof-by-arithmetic argument is surprising, however, given its reliance on the rather dubious linguistic assumption that numeric quantifiers in noun phrases must be given a bilateral "*exactly*" reading, as one would assign to numbers in simple arithmetic. Linguists agree that interpretations of numeric quantifiers are variable, affected by semantic and pragmatic considerations. One (neo-Gricean) set of accounts posits that numeric quantifiers have a unilateral, lower-bound "*at least*" semantics, with bilateral interpretations derived by coupling the lower-bound semantics with an upper-bound ("*at most*") conversational implicature (Horn, 1989; cf. Horn, 1992; Levinson, 2000). An alternative account by Breheny (2008) proposes that numeric quantifiers have a bilateral semantics but that they could yield unilateral interpretations via pragmatic inferences (for reviews of yet other accounts, see Carston, 1998; Geurts, 2006). In spite of the differences among these accounts, all agree that numeric quantifiers can take on unilateral or bilateral meanings under particular conditions. Stated differently, all accounts reject *naïve bilateralism*, the assumption that reasonable people ought to, and will, interpret numeric quantifiers as exact values. Nor is the objection to naïve bilateralism purely theoretical. For instance, even 5-year-olds with a good understanding of a context can use pragmatic inferences to arrive at multiple meanings of numbers including *exactly*, *at least*, and *at most* (Musolino, 2004).

Linguists also agree that when quantities are interpreted unilaterally, they tend to be lower- rather than upper-bounded. This prediction at least partially reflects the scalar property that higher scale values imply lower ones but not vice versa. Thus, for the positive scale {some, all}, if it is true that *all* were present, it is also true that *some* were. Likewise, if *at least* 200 lives were saved, it is also true that one or more sets of exactly 200 lives were saved. The same does not hold for the upper bound: If *at most* 200 lives were saved, it is possible, perhaps even probable, that no set of 200 lives was saved. Supporting this view, Halberg and Teigen (2009) found that, in various tests using Internet searches, lower-bound scalar modifiers (e.g., *more than*) are more frequently coupled with numbers than their upper-bound counterparts (e.g., *less than*). Moreover, consistent with lower- but not upper-bounding, participants who considered a financial version of the ADP judged predictions that fell short of the true value to be less accurate than predictions that surpassed that value by the same amount (Teigen & Nikolaisen, 2009).

The Present Research

Surprisingly, even those few authors who have questioned the extensional equivalence assumption (e.g., Jou et al., 1996; Kühberger & Tanner, 2010; Macdonald, 1986; Mandel, 2001) have not directly examined participants' linguistic interpretations of numeric quantifiers in framing studies of decision making. Thus, the present research explored this important topic. It is proposed that when these linguistic effects are taken into account, a quite different view of human decision making emerges—one where, generally speaking, decision makers' choices are rational. Specifically, it is proposed that when the meaning of numeric quantifiers in the certain options of the ADP (or an ADP variant, as examined in some of the present experiments) is linguistically modified so that it is clear that a bilateral "exactly" interpretation is appropriate, choices will tend to be consistent across frames, as the description invariance principle requires. Given that frames also leak information that go beyond the purely descriptive content of a statement (Sher & McKenzie, 2006, 2008, 2011), one might still expect some effect of framing even when a bilateral interpretation is adopted. However, bilateral interpreters should at least show significantly attenuated framing effects in their pattern of choice between options.

The present account also predicts that when those same quantifiers are modified such that they have a lower-bounded "at least" interpretation, a pattern of choice consistent with the framing effect will be observed. This is because, under those conditions, the expected number of lives saved ought to be maximized by choosing the certain option in the positive frame and the uncertain option in the negative frame. That is, in the lower-bounded positive "frame," the certain option offers an expectation of saving 200 lives *minimum*, whereas the uncertain option offers an expectation of saving *precisely* 200 lives. In contrast, the lower-bounded negative "frame" offers an expectation of saving 200 lives *maximum* compared to an expectation of saving *precisely* 200 lives in the uncertain option.[2] Under these conditions, it is rational (viz., "utility maximizing") to switch, and doing so in no way violates the description-invariance principle because the two certain options are not the same (hence the earlier use of scare quotes around the term "frame").

Experiment 1 tested these predictions using the ADP in a within-subjects design, whereas Experiment 2 generalized the results using a variant of the ADP in a between-subjects design. Experiment 3 examined participants' interpretations of numeric quantifiers when they were left linguistically unmodified. Consistent with the aforementioned prediction, it was hypothesized that, in Experiment 3, a pattern of choice consistent with a standard framing effect in which the certain option is more preferable in the positive-framing condition than in the negative-framing condition would be evident only among participants who interpreted the numeric quantifiers as lower bounds and, thus, for whom that pattern of choosing would maximize the expected number of lives saved (hereafter described as the *expected-value-maximizing* [EVM] *choice*).

To sum up, the present research aims to examine empirically for the first time using a variety of experimental methods whether the extensional-equivalence assumption is tenable and whether the conclusions that have been drawn from framing research about human (ir)rationality are indeed valid. It is perhaps worth noting, as well, to avoid possible confusion, at least one aim that the present research does not seek to achieve. That is, it does not aim to show that framing effects, in general, are not real. To the contrary, this work has very much been motivated by respect for the theoretical and practical significance of the class of phenomenon captured by the term framing, and by a corresponding desire to correct possible misconceptions regarding the causes and diagnostic implications of framing effects so that the scientific study of framing rests on firm analytical ground.

Experiment 1

Using a within-subjects design, akin to that employed by other researchers seeking to examine coherent choice at the participant level (e.g., Schneider, 1992; Stanovich & West, 1998), Experiment 1 tested the prediction that most participants would choose consistently across frames when the numeric quantifiers in the certain option were given a bilateral meaning (consistent with the description invariance principle), and that most participants would show a standard framing effect when the same quantifiers were explicitly lower-bounded (consistent with making EVM choices). These two patterns of choice exemplify rational choice.

Experiment 1 also estimated the frequencies of what might be called *excusable* and *inexcusable* choices—choices that violate requirements of rational choice, but which do so with different levels of justification. In the present research, excusable patterns of choice may come in two types: (a) excusable consistencies in which the first choice made is EVM and the second remains consistent even though it is not EVM and (b) standard framing effects made when the numeric quantifiers are given a bilateral meaning. The former are excusable because the second choice appears to sacrifice EVM for apparent consistency. Doing so does not justify the choice, but it does make it excusable. Arguably, standard framing effects are also excusable because even when the frames are extensionally equivalent, they "leak" information that, among other things, may imply a recommendation in favor of the certain option in the positive frame and a recommendation against

[2] These statements about maximum and minimum numbers of lives expected to be saved are predicated on the following semantics of superlative quantifiers: "'At least *n* A are B' means that the speaker is *certain* that there is a set of As that are B, and considers it *possible* that there is a larger set of As that are Bs. 'At most *n* A are B' means that the speaker considers it *possible* that there is a set of *n* As that are B, and is *certain* that there is no larger set of As that are B" (Geurts, Katsos, Cummins, Moons, & Noordman, 2010, p. 132).

that option in the negative frame (e.g., McKenzie & Nelson, 2003; Sher & McKenzie, 2006, 2008, 2011; van Buiten & Keren, 2009). Again, this does not justify such choice inconsistencies, which would nevertheless violate the description invariance principle, but it does make them excusable.

Inexcusable patterns of choice also come in two types: (a) reversed framing effects that either violate coherence requirements (when quantifiers have a bilateral meaning) or EVM (when quantifiers have a lower-bound meaning) and (b) consistent choices made when quantifiers are lower-bounded where the initial choice is not EVM (i.e., consistently choosing the certain option when the first frame is negative or consistently choosing the uncertain option when the first frame is positive). These choice patterns appear inexcusable because they are neither supported by a plausible reason that is noble (such as wanting to be consistent) nor pragmatic (such as reasonably reading "leaked information").

A final aim of Experiment 1 was to examine whether participants' rationality in decision making was related to individual differences in need for cognition (NFC; Cacioppo, Petty, & Kao, 1984) and experimental satisficing (Oppenheimer, Meyvis, & Davidenko, 2009). NFC measures an individual's motivation to engage in mentally challenging activities and reflective thought. LeBoeuf and Shafir (2003) found that high-NFC participants were less likely to violate description invariance in framing tasks than low-NFC participants. Likewise, West et al. (2008) reported a small but significant correlation between consistent choice in the ADP and a composite of NFC and a related openness measure. However, others (Levin, Gaeth, Schreiber, & Lauriola, 2002; Peters & Levin, 2008) have found that NFC was not related to coherence violations due to framing. Likewise, Mandel (2005) found no significant correlation between NFC and the magnitude of additivity violations in probability judgment (i.e., a different coherence measure).

Regarding the other measure, Oppenheimer et al. (2009) developed a simple one-item test of whether participants use a satisficing strategy in experimental tasks. Although the instructional manipulation-check (IMC) task seems to require participants to indicate all the sports from a list that the participant plays regularly, the instructions actually ask the participant to simply click the heading at the top of the screen. Correct responders were more sensitive to slight wording manipulations that have been shown to yield predictable effects, such as willingness to pay more for the same drink when it is purchased from a fancy resort as opposed to a run-down grocery store (Thaler, 1985). In one experiment by Oppenheimer et al. (2009), correct responders scored higher in NFC than incorrect responders, but that effect was not replicated in a second experiment. Given the linguistic manipulation in Experiment 1, the IMC task was included.

Method

Participants. One hundred twenty undergraduates were recruited from the general student population at University of Guelph and paid $20 to complete the experiment. Mean age of the sample was 20.48 years ($SD = 1.68$), and 54% were female. Sample size was determined using a combination of power analysis and heuristic strategy. For the primary analysis comparing independent proportions of consistent choosers in the exactly and at-least conditions, it was estimated that for an effect in which 2/3 of participants are consistent in the exact condition and 1/3 are consistent in the at-least condition, a minimum sample size of 84 is required for ensuring a Type I and Type II error rates of .05 and .10, respectively. Given that additional within-condition analyses of proportions were also of interest, the between-subjects conditions were increased from 42 to 60 participants each in order to improve stability of those finer comparisons.

Design. Experiment 1 used a 2 (Frame: positive, negative) × 2 (Modifier: at least, exactly) design, with frame manipulated within-subjects and modifier manipulated between-subjects.

Procedure and materials. Participants were randomly assigned to the between-subjects factor. The order in which framing conditions were presented was counterbalanced across participants. All participants were first given the ADP in one frame. The only variation from the original problem was whether the numeric quantifier (200 or 400) in the certain option was modified by the term "at least" or "exactly." After reading the problem, participants indicated which option of the two options they favored. The second ADP was given in the other frame and modified in the same way as the first problem. Between the first and second ADP tasks, participants completed a set of unrelated tasks involving the translation of verbal probabilities into numeric probabilities and they also completed Cacioppo et al.'s (1984) 18-item NFC scale. The intervening tasks took approximately 40 min to complete. Oppenheimer et al.'s (2009) IMC task was administered after the second ADP was completed. The experiment was run in a supervised laboratory on Macbook computers using FluidSurveys scripts. Participants had to complete all questions on any given page before the script would advance to the next page. Participants could not go back to review or change answers on previous pages.

Analysis. Selections of the certain and uncertain options were dummy coded as 1 and -1, respectively. A measure of framing effects was taken by subtracting the value in the negative-framing condition from that in the positive-framing condition. Thus, a positive value of 2 reveals a standard framing-effect pattern, a value of 0 reveals consistent choosing (i.e., a null framing-effect pattern), and a value of -2 reveals a reversed framing-effect pattern.

Results and Discussion

As predicted, the distribution of choice patterns was contingent on the linguistic modifier that appeared in the certain option of the ADP (see Table 1), $\chi^2(2, N = 120) = 24.68$, $p < .001$, $\phi = .45$. As Table 1 shows, when the numeric quantifiers were lower-bounded, a statistically significant majority (67.7%) showed a standard framing effect, consistent with an EVM choice pattern. However, when the same quantifiers had a bilateral meaning, an even greater majority (73.3%) showed consistent choice across the two decision-making problems. In other words, when the two options had equal expected value, most participants chose consistently across frames in line with the description invariance principle.

Table 1 also reveals that 31.7% (19/60) of participants in the *at-least* condition made consistent choices. Among this subsample, it is useful to distinguish those who made an EVM choice on the first problem and then opted to remain consistent on the second problem (an excusable pattern of choice) from those who did not

Table 1
Percent Distribution of Choice Patterns by Modifier in Experiment 1

	Modifier					
	At least		Exactly		Overall	
Choice pattern	%	95% CI	%	95% CI	%	95% CI
Standard framing effect	66.7	[54.1, 77.3]	21.7	[13.1, 33.6]	44.2	[35.6, 53.1]
Consistent choice	31.7	[21.3, 44.2]	73.3	[61.0, 82.9]	52.5	[43.6, 61.2]
Reversed framing effect	1.7	[0.3, 8.9]	5.0	[1.7, 13.7]	3.3	[1.3, 8.3]

make an EVM choice initially but chose to remain consistent on the second problem (an inexcusable pattern). In fact, a significant majority of those 19 participants made an initial EVM choice (78.9%, 95% CI [56.7%, 91.5%]). Over all participants in Experiment 1, then, 70.0% made rational choices, 23.3% made excusable choices, and the remaining 6.7% made inexcusable choices. The 95% confidence intervals for these three groupings are as follows: rational [61.3%, 77.5%], excusable [16.7%, 31.7%], and inexcusable [3.4%, 12.6%].

NFC did not significantly differ between participants who made rational choices ($M = 1.01$, $SD = 1.12$) and those who did not ($M = 1.09$, $SD = 0.87$), $t(118) = 0.39$. Likewise, IMC responses were independent of whether or not participants made rational choices, $\chi^2(1, N = 120) = 1.13$, $p = .29$. Finally, consistent with Oppenheimer et al. (2009, Experiment 2), there was no significant difference in NFC between the 19% who responded incorrectly on the IMC and the 81% who responded correctly, $t(118) = -0.55$. Thus, decision makers' rationality in problems like the ADP does not seem to be well captured by variables measuring one's motivation to think deeply, in general, or during an experiment, in particular.

Experiment 2

Experiment 2 was aimed at replicating the linguistic modifier effect in a between-subjects design using a modified decision problem. As other have noted (e.g., Geurts, 2013; Kühberger, 1995; Mandel, 2001; Teigen, 2011), an accurate forecast of an exact number of threatened lives (viz., 600) in the ADP is unrealistic. Yet, tests of coherence in that problem assume a set of exactly 600 threatened lives. To make this assumption more plausible, Mandel (2001) devised a modified scenario in which 600 people's lives were already threatened in a war-torn region and he showed that the problem yielded a standard framing effect when the options were worded as in the ADP. The present account predicts a standard framing effect when the quantifier in the certain option was not explicitly modified (as in the original ADP). The same pattern of choice should also be evident when the quantifiers are explicitly lower-bounded because that pattern reflects EVM choices. Indeed, it was predicted that the effect would be even stronger in the "at least" condition because the rational basis for the choice reversal is explicit. Finally, a significantly attenuated or even null framing effect was predicted when that quantifier was given a bilateral meaning.

Method

Participants. Two hundred twenty-eight undergraduates were recruited from three North American university campuses. The mean age of the sample was 20.01 years ($SD = 3.53$), and among those who indicated their gender 59% were female. A power analysis for the predicted interaction effect using analysis of variance (ANOVA) estimated that a minimum of 34 participants per condition were required to ensure Type I and Type II errors rates of .05 and .10 assuming a medium effect size ($f = .25$). The slightly larger number of participants recruited was due to overbooking.

Design. Experiment 2 used a 2 (Frame: positive, negative) × 3 (Modifier: none, exactly, at least) between-subjects design.

Procedure and materials. Participants were randomly assigned to one of the six conditions. On a sheet of paper, they were presented with the following cover story:

> In a war-torn region, the lives of 600 stranded people are at stake. Two response plans with the following outcomes have been proposed. Assume that the estimates provided are accurate.

In the positive-framing conditions, participants were presented with these options:

> If Plan A is adopted, it is certain that (exactly) [at least] 200 people will be saved.
>
> If Plan B is adopted, there is a one-third probability that all 600 will be saved and a two-thirds probability that nobody will be saved.

In the negative-framing conditions, participants were presented with these options:

> If Plan A is adopted, it is certain that (exactly) [at least] 400 people will die.
>
> If Plan B is adopted, there is a two-thirds probability that all 600 will die and a one-third probability that nobody will die.

Participants in the no-modifier condition were simply presented with the original options (omitting the modifiers shown in parentheses and brackets).

These option sets are similar to those in the ADP but for two exceptions. First, Option A states "it is certain that . . . ," which makes the assumed certainty of stated outcome explicit. Second, in the negative-framing condition, the uncertain option expresses the negative possible outcome first. In the ADP, the positive outcome is stated first, even in the negative frame. The later change was mainly precautionary, however, as Peters and Levin (2008) reported no effect of ordering on attractiveness ratings of the risky option in the ADP.

After considering the problem, participants were first asked, "Which of the two plans would you choose—A or B?" Next, they were asked, "How much more preferable is the plan that you chose compared with the plan that you did not choose?" They responded on an 11-point scale (0 = *equally preferable*, 10 = *much more preferable*). A measure of weighted choice was later computed by dummy coding the choices favoring the certain and uncertain options as 1 and −1, respectively. Those values were multiplied by the preference rating, yielding values between −10 and 10. An advantage of this measure is that it allows participants to indicate that, although they made a forced choice, they may in fact have been indifferent between the two options. This is important because even when participants are indifferent between two options, they may choose systematically when forced to make a binary choice (Mandel, 2003). The weighted measure also facilitated the analysis of interaction effects, which are of primary concern here (see Peters & Levin, 2008, for a similar approach).

Results and Discussion

A Frame × Modifier ANOVA revealed a main effect of frame, $F(1, 222) = 38.40$, $p < .001$, $\eta_p^2 = .15$, and a main effect of modifier, $F(2, 222) = 3.62$, $p = .028$, $\eta_p^2 = .03$. These effects were qualified by the predicted two-way interaction effect, $F(2, 222) = 6.59$, $p = .002$, $\eta_p^2 = .06$. Table 2 shows the percentage of participants who chose the certain option and mean weighted choice as a function of frame and modifier, as well as statistics for interpreting the simple effects of framing (viz., mean difference between framing conditions and 95% CIs). The interaction effect confirms the expected pattern of simple effects: When the quantifier in the certain option was left unmodified, there was a medium-sized, standard framing effect, $F(1, 74) = 8.53$, $p = .005$, $d = 0.67$. In contrast, when the same quantifiers were given a bilateral meaning, the framing effect was nonsignificant, $F(1, 74) = 1.36$, $p = .25$, $d = 0.27$. Finally, when the quantifier in the certain option was lower-bounded, there was a large effect consistent with a standard framing pattern, $F(1, 74) = 55.46$, $p < .001$, $d = 1.75$. Moreover, a significant majority of participants in the at-least condition (79%, 95% CI [69%, 87%]) made EVM choices (i.e., by choosing the certain option in the positive frame and uncertain option in the negative frame). These findings thus offer additional support for the view that most decision makers choose rationally in problems like the ADP. Most participants maximized expected value when possible (i.e., when the quantifiers were lower-bounded) and there was no evidence of invariance violations when the quantifiers were given a bilateral meaning.

Experiment 3

Experiments 1 and 2 offer evidence suggesting that claims of irrationality in decision making based on framing studies may have been exaggerated in previous literature. Those findings, however, do not directly address the earlier critique that the proof-by-arithmetic argument and the extensional-equivalence assumption it supports rest on an untenable linguistic assumption—namely, naïve bilateralism. The aim of Experiment 3 was to address those claims directly by examining how people spontaneously interpret numeric quantifiers that, in turn, shape the valuation of options in decision-making problems like the ADP. Moreover, Experiment 3 examined how those interpretations vary as a function of linguistic aspects of such problems that have received relatively little attention. Specifically, whereas the uncertain options in the ADP explicate the probabilities of both the favorable (600 saved) and unfavorable (600 die) possible outcomes, the certain options only explicate part of the expected outcome. That is, nothing is said about the remaining 400 lives in Option A or about the remaining 200 lives in Option C. However, when that asymmetry was eliminated, the framing effect disappeared (Kühberger, 1995; Kühberger & Tanner, 2010; Mandel, 2001).

Building on that explication effect, it was predicted that variations in the explication of the options would also influence the interpretation of numeric quantifiers used to describe the expected outcomes of those options. Specifically, Experiment 3 tested the hypothesis that the proportion of participants interpreting numeric quantifiers as lower bounds would be greater when the expected outcomes were partially explicated (e.g., "If Program A is adopted, 200 lives will be saved") rather than fully explicated (e.g., "If Program A is adopted, 200 lives will be saved and 400 lives won't be saved") because only with full explication is it explicit that the exact number of lives expected to be saved and to die sum to the total set of 600. Indeed, it is predicted that, whereas most participants will interpret the certain option's quantifiers bilaterally in the fully explicated version, most will interpret those quantifiers as lower bounds in the partially explicated version, contrary to naïve bilateralism. Stated differently, the integrity of a framing manipulation—namely, ensuring that alternative frames are extensionally equivalent—should be promoted by fully explicating choice options to prospective decision makers. Conversely, partial explications of choice options, both the certain and risky options, should increase the likelihood that they will be interpreted in a single-bounded manner, thus undermining the integrity of any intended framing manipulation.

A related aim of Experiment 3 was to examine how quantifier interpretations (both of the integers in the certain options and of the probabilities in the uncertain options) might moderate the framing effect. In line with the hypothesis of EVM choosing, it was predicted that the option of saving 200 lives would be per-

Table 2
Percentage Choosing the Certain Option (% A) and Mean Weighted Choice by Frame and Modifier in Experiment 2

	Frame							
	Negative			Positive				
Modifier	% A	*M*	*SD*	% A	*M*	*SD*	Δ*M*[a]	95% CI
None	26.3	2.79	5.66	57.9	−0.89	5.33	3.68	[1.17, 6.19]
Exactly	43.2	0.09	5.31	59.0	−1.28	4.97	1.37	[−0.98, 3.72]
At least	32.5	2.45	4.77	91.7	−4.75	3.48	7.20	[5.30, 9.10]

[a] Δ*M* is the mean difference in weighted choice (mean in the negative frame minus mean in the positive frame).

ceived as least favorable when it was upper-bounded (i.e., at most 200 saved) and most favorable when it was lower-bounded (i.e., at least 200 saved), and vice versa for the option of losing 400 lives. Likewise, it was predicted that a 1/3 probability of saving everybody would be perceived as least favorable when it was upper-bounded (i.e., at most a 1/3 probability of saving 600) and most favorable when it was lower-bounded (i.e., at least a 1/3 probability of saving 600), and vice versa for a 2/3 probability of everybody dying. It follows from these predictions that a standard framing effect would be seen mainly among lower-bound interpreters of the certain options and upper-bound interpreters of the uncertain options.

Method

Participants. One hundred forty-seven undergraduates at University of Victoria were recruited from the psychology department participant-research pool and received partial course credit for participating. Age was not recorded, and 66% were female. An estimate of 144 participants required was based on a sample-size calculation that assumes Type I and Type II error rates of .05 and .10, respectively, with $f = .30$. The actual sample size reflects slight oversampling.

Design. Experiment 3 used a 2 (Frame: positive, negative) × 3 (Explication: A-partial/B-full, A/B-full, A-full/B-partial) between-subjects design.

Procedure and materials. In a paper-and-pencil task, participants were asked to read the decision problem used in Experiment 2, and framing was manipulated in the same manner. Participants were presented with two options whose wording depended on the experimental condition to which they were assigned. The explication factor manipulated which of the two options was partially explicated and which was fully explicated in terms of expected outcomes. Specifically, in the positive A/B-full condition, participants read these options, including the parenthesized material:

> If Plan A is adopted, it is certain that 200 people will be saved (and 400 people will not be saved).
>
> If Plan B is adopted, there is a 1/3 probability that all 600 will be saved (and a 2/3 probability that nobody will be saved).

In the negative A/B-full condition, participants read these options, again including the parenthesized material:

> If Plan A is adopted, it is certain that 400 people will die (and 200 people will not die).
>
> If Plan B is adopted, there is a 2/3 probability that all 600 will die (and a 1/3 probability that nobody will die).

In the A-partial/B-full condition, as in the ADP, the parenthesized material in Option A was excluded. In the A-full/B-partial condition, the parenthesized material in Option B was excluded, reversing the asymmetry in the ADP.

As in Experiment 2, participants first made a binary choice and then rated their strength of preference for the selected option. Next, participants were asked about their interpretations of the two options. First, they were asked: "Did you interpret Plan A to mean (a) at most, (b) exactly, or (c) at least (200 will be saved) [400 will die]?" Then, they were asked: "Did you interpret Plan B to mean there was (a) at most, (b) exactly, or (c) at least a (1/3 probability that all 600 people will be saved) [2/3 probability that all 600 people will die]?"

Results

The explication effect. As noted earlier, manipulations of explication have moderated the framing effect in previous research (Kühberger, 1995; Kühberger & Tanner, 2010; Mandel, 2001). The initial analysis tested whether this explication effect was replicable. A Frame × Explication ANOVA on weighted choice revealed that only the predicted interaction effect was significant, $F(2, 141) = 9.41$, $p < .001$, $\eta_p^2 = .12$. Table 3 shows the percentage of participants who chose the certain option and mean weighted choice by frame and explication, as well as statistics for interpreting the simple effects of framing (viz., mean difference between framing conditions and 95% CIs). As one might expect, in the standard (A-partial/B-full) format, a standard framing effect was replicated, $F(1, 48) = 21.21$, $p < .001$, $d = 1.30$. Replicating previous findings, when both options were fully explicated, the framing effect was eliminated, $F(1, 46) = 0.06$, $p = .81$, $d = 0.07$. Finally, when the explication asymmetry was reversed (A-full/B-partial)—a condition not previously investigated—so was the direction of the "framing effect" (the scare quotes are meant to underscore that, strictly speaking, the alterative descriptions may not qualify as alternative frames; i.e., they may not be extensionally equivalent): With medium effect size, the uncertain option was marginally *less* preferable in the negative condition than in the positive condition, $F(1, 49) = 2.99$, $p = .09$, $d = -0.48$. To sum up, the explication effect appears to be robust and even more consequential than previously thought because reversals of the explication asymmetry actually reversed the framing effect.

Explication effects on interpretation. Table 4 shows participants' quantifier interpretations as a function of explication and the option in which the quantifier appeared. As predicted, the percentage of participants who had a lower-bound interpretation of the certain option was significantly greater (and a significant majority) when that option was partially explicated (64%, 95% CI

Table 3
Percentage Choosing the Certain Option (% A) and Mean Weighted Choice by Frame and Explication in Experiment 3

	Frame							
	Negative			Positive				
Explication	% A	*M*	*SD*	% A	*M*	*SD*	ΔM[a]	95% CI
A-partial/B-full	20.0	3.92	5.37	68.0	−2.92	5.13	6.84	[3.85, 9.83]
A/B-full	50.0	0.00	6.38	59.1	−0.41	5.41	0.41	[−3.10, 3.92]
B-partial/A-full	68.0	−1.48	5.95	42.3	1.38	5.89	−2.86	[−6.19, 0.47]

[a] ΔM is the mean difference in weighted choice (mean in the negative frame minus mean in the positive frame).

Table 4
Percent Distribution of Interpretations by Explication and Option in Experiment 3

Option	Explication	*N*	Interpretation: At least	Exactly	At most
Certain (A)	A-partial/B-full	50	64.0	30.0	6.0
Certain (A)	A/B-full	46	23.9	58.7	17.4
Certain (A)	B-partial/A-full	51	23.5	62.7	13.7
Uncertain (B)	A-partial/B-full	49	26.5	42.9	30.6
Uncertain (B)	A/B-full	46	17.4	47.8	34.8
Uncertain (B)	B-partial/A-full	51	37.3	45.1	17.6

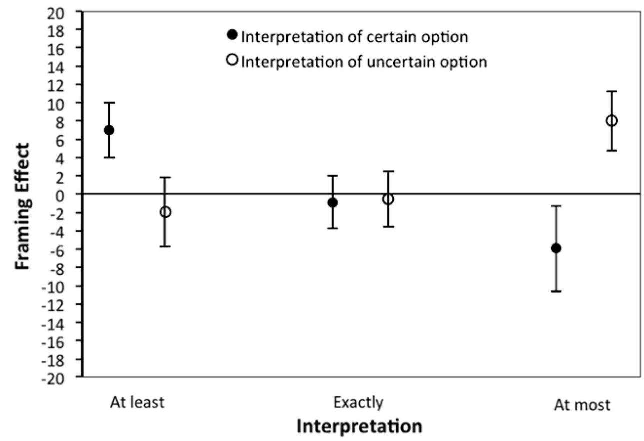

Figure 1. Direction and magnitude of framing effect by participants' interpretations of the certain and uncertain options in Experiment 3. Error bars show 95% confidence intervals on the difference between mean weighted choice in the negative and positive framing conditions. Positive values show standard framing effects where there is a stronger preference for the certain option in the positive frame than in the negative frame. Negative values show reversed framing effects. The *y*-axis shows the possible range of effects.

[50%, 76%]) than when it was fully explicated (24%, 95% CI [16%, 33%]), $p < .001$ by one-sided Fisher's Exact Test. In contrast, but also as predicted, when the certain option was fully explicated, a significant majority of participants interpreted the same quantifiers bilaterally (62%, 95% CI [52%, 71%]). The effect of explication on the tendency to lower-bound quantifier interpretations was not dependent on frame. For instance, examining the effect size of this contingency, $\phi = .36$ in the positive-framing condition, and $\phi = .43$ in the negative-framing condition, the difference is not significant ($z = -0.49$, $p = .62$).

A majority of participants had a bilateral interpretation of probability quantifiers regardless of whether the uncertain option was partially or fully explicated. Nevertheless, as predicted, the percentage having a lower-bound interpretation of the probability quantifiers was significantly greater when the uncertain option was partially explicated (37%, 95% CI [25%, 51%]) rather than fully explicated (22%, 95% CI [15%, 31%]), $p = .04$ by one-sided Fisher's Exact Test. Once again, this effect was not frame dependent: $\phi = .15$ in the positive-framing condition, and $\phi = .18$ in the negative-framing condition ($z = -0.18$, $p = .86$).

To sum up, the findings indicate that most people do not treat quantifiers such as 200 and 400 in problems like the ADP as exact values. Rather, most interpret them as lower bounds. Moreover, the findings clearly show that quantifier interpretations depend on other linguistic factors such as the extent to which a description fully explicates its referents. Finally, it appears that probability quantifiers are less likely than cardinal quantifiers to be interpreted unilaterally, perhaps because they evoke more of a statistical mindset.

Interpretation effects. A key prediction of this experiment was that participants' quantifier interpretations would moderate the framing effect in a manner consistent with EVM choice. As noted earlier, that would entail two opposing patterns of interaction effects. First, for interpretations of the certain option, the EVM hypothesis predicts a standard framing effect for lower-bound interpreters, no framing effect for bilateral interpreters, and a reversed framing effect for upper-bound interpreters. Second, for interpretations of the uncertain option, the EVM hypothesis predicts a reversed framing effect for lower-bound interpreters, no framing effect for bilateral interpreters, and a standard framing effect for upper-bound interpreters. Figure 1 plots the observed simple effects of framing as a function of participants' quantifier interpretations of both options. As can be seen, the crossover interaction of interactions strongly supports the predicted pattern. Providing additional detail, Table 5 shows the percentage of participants who chose the certain option and mean weighted choice as a function of the interaction terms.

Inferential tests confirm what is visually evident from Figure 1. As predicted, for the certain option, a Frame × Interpretation ANOVA revealed only a significant interaction effect on weighted choice, $F(2, 141) = 12.13$, $p < .001$, $\eta_p^2 = .15$. Among lower-bound interpreters of the certain option, there was a standard framing effect, $F(1, 53) = 26.13$, $p < .001$, $d = 1.37$. Yet, among bilateral interpreters, the framing effect was eliminated, $F(1, 72) = 0.40$, $p = .53$, $d = -0.15$. And, among upper-bound interpreters, the framing effect was reversed, $F(1, 16) = 7.38$, $p = .02$, $d = -1.34$. For the uncertain option, once again, only the predicted interaction effect was significant, $F(2, 140) = 9.29$, $p < .001$, $\eta_p^2 = .12$. Among lower-bound interpreters, there was a small, but non-significant, reversed framing effect, $F(1, 38) = 1.25$, $p = .27$, $d = -0.35$. Among bilateral interpreters, the framing effect was

Table 5
Percentage Choosing the Certain Option (% A) and Mean Weighted Choice by Frame and Interpretation in Experiment 3

Interpretation	Negative: % A	Negative: *M*	Negative: *SD*	Positive: % A	Positive: *M*	Positive: *SD*
Certain option						
At least	26.9	3.31	5.62	82.8	−3.66	4.47
Exactly	52.6	−0.08	6.36	44.4	0.83	5.97
At most	70.0	−2.20	5.71	12.5	3.75	2.60
Uncertain option						
At least	62.5	0.73	6.25	41.7	−0.63	5.71
Exactly	52.8	−0.36	6.04	46.7	0.17	6.22
At most	23.8	3.67	6.00	89.5	−4.32	3.94

eliminated, $F(1, 64) = 0.12$, $p = .73$, $d = -0.09$. Finally, among upper-bound interpreters, a large standard framing effect was found, $F(1, 38) = 24.13$, $p < .001$, $d = 1.57$.

Finally, a separate analysis of cases in which participants had bilateral interpretations of both options was conducted. That subsample defines those participants for whom the extensional-equivalence assumption and proof-by-arithmetic argument should presumably ring true. Do these participants show a framing effect? Remarkably, they show a *reversed* framing effect of medium size and marginal significance: Participants in the negative-framing condition ($M = -1.52$, $SD = 6.01$) preferred the certain outcome, whereas those in the positive-framing condition preferred the uncertain outcome ($M = 1.67$, $SD = 6.13$), $F(1, 42) = 3.03$, $p = .09$, $d = -0.53$, 95% CI [−0.51, 3.70].

Rational-choice analysis. Building on the main analyses of the preceding subsection, the present analysis directly tests the EVM hypothesis by examining participants' choices contingent on their joint interpretations of the quantifiers in the two options presented to them. As Table 6 shows, of the 18 conjunctions in a 2 (Frame) × 3 (Interpretation of Option A) × 3 (Interpretation of Option B) matrix, six favor the certain option (A), six favor the uncertain option (B), and six are indeterminate (i.e., where both options are interpreted in the same manner). As predicted, among the determinate cases ($n = 87$), a significant majority of participants (76%, 99% CI [66%, 84%]) made EVM choices. Moreover, the 24% minority of suboptimal choosers were not systematically affected by frame, with the certain option being chosen by 44.4% in the positive-framing condition and 58.3% in the negative-framing condition, $\chi^2(1, N = 21) = 0.40$, $p = .53$.

General Discussion

Few word problems in psychology have had the theoretical impact and widespread recognition that the ADP has had. Indeed, awareness of and fascination over the ADP has not only transcended behavioral decision research, it has transcended psychology. For instance, when Daniel Kahneman was awarded the Nobel Memorial Prize in Economics for his work with Amos Tversky on the psychology of decision making, *The New York Times* captured the essence of their contribution to understanding systematic departures from rationality in decision making with a single example—the ADP (Goode, 2002). The journalist made a point of writing that "the *exact same choice* [emphasis added] presented or 'framed' in different ways could elicit different decisions" (Goode, 2002, para. 12). This is not surprising given that the framing literature conveys an almost uniform acceptance of the extensional-equivalence assumption. Although there have been a few critical analyses of the assumptions underlying framing studies (e.g., Berkeley & Humphreys, 1982; Geurts, 2013; Macdonald, 1986; Mandel & Vartanian, 2011; Teigen, 2011), they have largely been absent of empirical tests of the soundness of that assumptive scaffolding. Such tests are important, however, precisely because the findings of framing studies have been treated as unquestioned demonstrations of irrationality in human decision making. Below, the implications of the findings from the present set of tests are discussed.

Table 6
Predicted Choices Based on the EVM Hypothesis

Interpretation of certain option (A)	Interpretation of uncertain option (B)		
	At least	Exactly	At most
Positive frame			
At least	I	A	A
Exactly	B	I	A
At most	B	B	I
Negative frame			
At least	I	B	B
Exactly	A	I	B
At most	A	A	I

Note. A = the certain option is the expected-value-maximizing (EVM) choice; B = the uncertain option is the EVM choice; I = an EVM choice cannot be defined (indeterminate).

Implications for the Assumptions Underlying Framing Research

As noted earlier, the verdict of irrationality drawn in the risky-choice framing literature rests on the extensional-equivalence assumption. That assumption, in turn, is supported by the proof-by-arithmetic argument, which relies on yet another assumption: naïve bilateralism. Although this argument structure is not difficult to map, it has remained largely implicit in the literature, and perhaps that is why it has not been adequately tested. The findings of Experiment 3 clearly refute the descriptive claim of naïve bilateralism. In the standard version of the decision task (paralleling the ADP), most participants treated the quantifier values of 200 and 400 in the certain option as lower bounds rather than as exact values. This finding converges well with both neo-Gricean theories of quantification (Horn, 1989; Levinson, 2000) and psychological research showing a tendency to interpret estimates as lower bounds (Teigen & Nikolaisen, 2009).

The lower bounding of numeric quantifiers in the standard version of the problem shows unequivocally that the extensional-equivalence assumption is untenable: Saving at least 200 lives out of 600 is clearly not the same thing in real terms as letting at least 400 die. The same finding also shows that the assumption that the two options presented to a given participant are of equal expected value is false because saving at least 200 lives for sure has greater expected value than a 1/3 chance of saving 600, whereas losing at least 400 lives for sure has lesser expected value than a 2/3 chance of losing 600. In short, the findings indicate that, for most people, Options A and C in the ADP are descriptions of different events, and not merely re-descriptions of the same event. Although effects of the usual ADP positive-negative manipulation are description effects, strictly speaking, they are not framing effects, and thus should not be labeled as such.

Some theorists might still want to accept naïve bilateralism as a prescriptive stance. That is, even if one were to concede that most people do not treat such values as exact, one might still argue that people should. For instance, Shafir and LeBoeuf (2002, p. 506) proposed that "conversational misinterpretations" could account for some coherence violations. Their choice of the term *misinterpretation* indicates such a prescriptive stance. In the present context, it implies that people who interpret numeric quantifiers as anything other than exact values are in some sense adhering to an inferior interpretation. Theorists who might wish to adopt such a view do not start out easily since that view challenges not only linguistic theories of quantification, but also deeper philosophical arguments holding that the meaning of words are definable only through their use in language (e.g., Wittgenstein, 1953). As Austin (1979) famously put it, "there is *no* simple and handy appendage of a word called 'the meaning of (the word) *x*'" (p. 62). Decision theorists who wish to be arbiters of linguistic meaning should practice restraint.

It is also worth reminding the reader that, although the focus in this research was on risky-choice framing, given the latter's relevance to the question of human rationality in decision making, the linguistic implications of how numeric quantifiers are interpreted revealed in the present research extend to other types of framing, including attribute and health message framing (see Levin et al., 1998), which, like risky-choice framing, often involve numeric quantification in language. In health message framing (e.g., Rothman & Salovey, 1997), alternative therapy options might be framed, for instance, in terms of the probability of dying from the treatment (mortality rate) or the probability of living for a given time after the treatment (survival rate). For example, a surgical procedure could be described as having a 10% mortality rate or a 90% survival rate post-surgery. If these quantities tend to be interpreted as lower bounds, then clearly the alternative frames would not convey the same information to patients because, in the former case, one would have *at least* a 10% chance of dying from the surgery, whereas, in the latter case, one would have *at most* a 10% chance. Similarly, in attribute framing (e.g., Levin & Gaeth, 1988), a food product that is described as 75% lean versus 25% fat would convey objectively different meanings if these quantifiers are interpreted as lower (or for that matter, upper) bounds. Thus, the present findings have implications for a wide array of everyday-life decision-relevant situations in which information pertinent to choice is communicated using numeric quantifiers.

Implications for Assessments of Rationality in Decision Making

The present findings shed light on the topic of how rational decision makers are in two important ways. First, because the findings of Experiment 3 show that a foundational assumption on which some past claims of decision-maker irrationality were based is wrong, they call for a reinterpretation of the findings on which those claims are based. At minimum, they suggest the need for greater caution in interpreting previous findings. For instance, they raise questions about the integrity of measures that use framing tests modeled on the ADP as indicators of cognitive (in)competence (e.g., Bruine de Bruin et al., 2007; West et al., 2008). Indeed, the present findings indicate that the construct validity of such measures could be improved by omitting such problems. Alternatively, researchers could strengthen the framing manipulations used in such measures by making explicit that the referenced quantities are exact values rather than lower or upper bounds (e.g., Mandel, 2008). As the present findings indicate, this adjustment in the context of gain-loss framing manipulations will likely reduce the frequency with which framing effects are observed. However, competence measures might be well informed by framing effects that the corrected methods reveal, given that they may actually improve their diagnostic value.

The present findings, however, also contribute to the rationality debate in a more positive sense by showing that a significant majority of participants made rational decisions by classical rational-choice criteria in traditional risky-choice framing problems. In Experiment 1, the majority chose consistently across frames when it was clear that the numeric quantifiers were to be interpreted as exact values. In other words, when the extensional-equivalence assumption held, most decision makers were coherent, adhering to the principle of description invariance. And, when expected value in terms of lives saved favored one option over another, most decision makers made EVM choices. The robustness of those findings was shown in Experiment 2, which varied the design (i.e., between-subjects), problem (i.e., by using an ADP isomorph), and dependent measure (i.e., weighted choice), yet which replicated the modifier by frame interaction effect. And, it was further tested in Experiment 3 by examining participants' choices contingent on their quantifier interpretations of the two options. That analysis once again revealed that most decision makers made EVM choices. In short, when ambiguity regarding the meaning of quantifiers used to convey the value of a given option was resolved (by the researcher in Experiments 1 and 2 and by participants themselves in Experiment 3), it was evident that most participants made substantively rational choices.

The findings of Experiment 1 also revealed that, among the minority of decision makers who did not make fully rational choices, most (78%) nevertheless made excusable errors. That is, they either followed an initial EVM choice with an ostensibly consistent choice, or they chose in a manner consistent with the recommended course of action conversationally implied by the choice of frame (Sher & McKenzie, 2008; van Buiten & Keren, 2009). Only a small percentage (about 7%) of the overall sample made what one might call irrational or inexcusable choices.

Relations to Alternative Theoretical Accounts of Framing Effects

The multiply moderated description effects shown in the present research were predicted on the basis of a rational-choice account informed by linguistic principles. The latter must be considered in contexts where decision-making problems are communicated to decision makers by problem formulators using written or spoken language. Without a clear understanding of how language in its communicative context shapes meaning (in the present context, the communicated value of choice options) it is all too easy for researchers to mistake rational choices for ostensibly irrational ones. Indeed, clarifying the communicative context can also result in ostensibly rational choices being redefined as irrational. For example, in within-subject experiments (e.g., Schneider, 1992; Stanovich & West, 1998), consistent choices (i.e., A–C or B–D patterns) are treated as rational, but as Experiment 1 revealed, such patterns are actually irrational when the quantifiers in the certain option are lower-bounded as they typically appear to be. More generally, the present account is conceptually aligned with literature underscoring the importance of understanding the conversational and linguistic context within which behavioral data are elicited (e.g., Fiedler, 2008; Hilton, 1995; Moxey & Sanford, 2000; Noveck & Reboul, 2008; Schwarz, 1996). That context is particularly important to bear in mind in experiments where alternative conditions are defined by subtle linguistic alterations, as is the case in most research on framing.

Although the present findings are well explained by a conversationally informed rational-choice account, it is important to consider how well alternative accounts of framing effects accommodate those findings. Tversky and Kahneman (1981) explained their original findings in terms of prospect theory (Kahneman & Tversky, 1979). Prospect theory posits an "S-shaped" value function in which subjective value is a concave function of utility for prospective gains and a convex function for losses, where the gain and loss domains are defined relative to a subjective reference point. According to this account, decision makers adopt a zero-lives-saved reference point when the options are positively framed and a zero-lives-lost reference point when they are negatively framed. Thus, decision makers are expected to behave as if they were in the gain domain in the former case and as if they were in the loss domain in latter case. Because of the value-function model's hypothesized inflection around the reference point, risk attitudes are predicted to vary such that decision makers would prefer the certain option to the uncertain option in the positive-framing condition and vice versa in the negative-framing condition. Although the value-function model does well at explaining the original effect, it cannot account for the multiply moderated framing effects shown in the present research. Indeed, it distinctly predicts a framing effect even when the quantifiers are interpreted bilaterally, and yet no framing effect was found under such conditions in the three experiments. Therefore, although prospect theory's value-function model has much evidence to support it from a wide range of experimental tasks (e.g., simple lotteries), it cannot accommodate the present findings.

The present account may also be contrasted with McKenzie and colleagues' (McKenzie, 2004; McKenzie & Nelson, 2003; Sher & McKenzie, 2006, 2008, 2011) *information leakage* (IL) account. Like the present account, the IL account emphasizes the importance of the communicative context within which the participant must act as a decision maker. The IL account proposes that, even if alternative frames are logically equivalent, they may be non-equivalent in terms of the information they convey because a speaker's choice of frame may communicate information that goes beyond the literal meaning expressed. The IL account proposes multiple pathways through which extensionally-equivalent frames may nevertheless be "information non-equivalent." Regarding ADP-style decision tasks, the IL account posits that positive frames convey a recommendation for the certain option, whereas negative frames convey a recommendation for the uncertain option (Sher & McKenzie, 2008; van Buiten & Keren, 2009). In this regard, the present account is in agreement with the IL account. Indeed, these IL tenets were used in Experiment 1 to differentiate excusable and inexcusable patterns of choosing. And, for the same reasons, it was predicted that, whereas bilateral interpretations of quantifiers in the sure options of ADP-style tasks would attenuate framing effects, such interpretations might not fully eliminate such effects.

However, the two accounts also differ in distinct ways. The IL account, for example, does not predict the moderation of the framing effect by explication (Experiment 3), linguistic modifier (Experiments 1 and 2), or participants' linguistic interpretations (Experiment 3), whereas these effects are predicted by the present account. Moreover, unlike the present account, the IL account accepts the extensional-equivalence assumption (e.g., Sher & McKenzie, 2008), which the present findings show is unfounded. Notwithstanding the differences, there are good prospects for these two accounts to mutually reinforce the other.

The present findings also bear on other linguistic proposals that have been made in the framing literature. For example, in an early critique of Tversky and Kahneman's (1981) framing-effect demonstration, Macdonald (1986) proposed that people normally add "or more" to numeric quantifiers. However, Macdonald never tested his proposal. Unlike Macdonald's proposal, the present account predicts that the interpretation of numeric quantifiers is not invariant. Just as the present account rejects naïve bilateralism, it also rejects naïve forms of unilateralism of the sort Macdonald proposed. The findings of Experiment 3 clearly show that, although most people adopt a lower-bound reading in the standard problem, most people also adopt a bilateral reading when the options are fully explicated. The moderation of quantifier interpretations based on linguistic context (i.e., whether frames are explicated partially or fully) also clearly indicates that numeric quantifiers are not coarsely interpreted as "some" for non-zero values, as Reyna and Brainerd (1991) had proposed. Contrary to the present findings, their fuzzy-trace account predicts no interaction effect of modifier and frame because "at least *n*" and "exactly *n*" should both have the same gist (viz., *some*).

It is likely that the narrative context matters as well. For instance, Bless, Betsch, and Franzen (1998) replicated the framing effect in the ADP when the top corner of the page was labeled "medical research," but found the effect eliminated when the label was changed to "statistical research." As Bless et al. acknowledged, their design did not allow them discover the mediating mechanism for the moderation they observed. A testable hypothesis is that the cue prompting a statistics narrative would make participants more likely to interpret quantifiers as exact values, whereas the cue prompting a health narrative would make them more likely to adopt a lower-bound reading as in the un-cued ADP. Likewise, Jou et al. (1996) found that the framing effect was eliminated in the ADP when a rationale for the options was provided such that there were only enough vaccines for 200 people. This rationale would seem to be most consistent with an "at most" interpretation in the positive frame and with an "at least" interpretation in the negative frame—a pattern that would be predicted to eliminate the framing effect because EVM choices should not vary by frame.

As an initial test of this prediction, 97 undergraduate student participants were given either the standard ADP cover story or a Canadianized version of Jou et al.'s (1996) ADP-with-rationale cover story. Participants were asked whether they thought the value stated in the certain option was "exactly" the number that would be saved or would be left to die, and they responded by selecting either a "no" or "yes" option. If they selected "no," then a follow-up question appeared, which asked participants whether they thought it was more likely that "at least" or "at most" the quantity specified in the certain option would either be saved or be left to die. In the standard ADP version, a majority responded "at least" in the positive (58%) and negative (54%) framing conditions. As predicted, however, in the with-rationale condition, a majority (71%) responded "at most" given the positive frame, whereas a majority (64%) responded "at least" given the negative frame. This demonstration shows that the interpretation of numeric quantifiers is predictably shaped by context in which such terms appear. Although a specification of how various types of context (e.g., conversational, semantic, and sentential) affect the interpretation of such terms is beyond the aims of this article, the present research, including the latter demonstration, suggests the need for a comprehensive psycholinguistic account of numeric quantifier use and interpretation. The studies reported here already show that quantifier interpretations are influenced by the degree to which descriptions of choice options are explicated (Experiment 3), by the type of quantifier (e.g., cardinal numbers vs. probabilities, as shown in Experiment 3), and by knowledge-based features of decision tasks (as the former demonstration revealed).

Meta-Theoretical Reflections

When Thomas Kuhn sought to understand what Aristotle had already explained about physics and what he had left to others like Galileo and Newton to discover, he was surprised to learn that much of what the great philosopher had said was wrong. That conclusion, however, did not sit well with him, for Kuhn knew that Aristotle had made important strides in understanding in other areas—how could he have been so misguided in physics, he thought (Kuhn, 2000). This and other puzzles of ostensible folly among many of history's great thinkers eventually led Kuhn to formulate his influential ideas about incommensurability and revolutionary change in science. Kuhn realized that thinkers in different time periods must have attached different meanings to some proportion of the words they held in common. Thus, to properly understand Aristotle's physics, one had to understand what Aristotle would have understood by his statements on the topic. Indeed, when Kuhn realized what certain terms like *motion* must have meant to Aristotle, he could appreciate afresh how sweeping Aristotle's physics actually was.

The theme of this article follows a parallel line of thinking, questioning the soundness of assuming that what an experimenter takes as the literal meaning of a given statement is what his or her participants would take as its literal meaning. Moreover, it questions the coherence of an inferential process that would rely on such an assumption. To explain the apparent ease with which researchers seem willing to invoke such assumptions, it is worth reconsidering William James's notion of the *psychologist's fallacy*. As James (1890/1950, p. 196, italics in original) wrote, "The *great* snare of the psychologist is the *confusion of his own standpoint with that of the mental fact* about which he is making his report. I shall hereafter call this the 'psychologist's fallacy' *par excellence*."

In the present context, the psychologist's fallacy occurs when researchers project their understanding of the ADP in terms of the proof-by-arithmetic argument onto the participant and then goes on to evaluate the coherence of the participant's choices as if that understanding were in fact the participant's own. This type of objection (e.g., Berkeley & Humphreys, 1982; Henle, 1962; Hilton, 1995; Phillips, 1983) has been variously called the structure argument (Jungermann, 1983) or the alternative-task-construal argument (Stanovich & West, 2000), and it has often been characterized as a strategy of "optimists" or "apologists" designed to challenge allegations of irrationality in human judgment and decision making. That characterization is regrettable because attention to the psychologist's fallacy (or the problem of making assumptions regarding inter-subjectivity) is principally aimed at improving the conceptual rigor of research and theory, which one can only hope reflects a bipartisan aspiration widely shared across meta-theoretical camps.

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Received September 6, 2012
Revision received July 25, 2013
Accepted July 26, 2013 ■